Agglomeration Economies and Entrepreneurship in the ICT Industry

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Agglomeration Economies and Entrepreneurship in the ICT Industry[1]

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Abstract
In this study indicators of agglomeration economies and their effect on entrepreneurship in the ICT industry are analysed in diverse urban contexts. Agglomeration economies have a stronger impact on new firm formation than on the growth of incumbent firms. Concentration and diversity both have a positive effect on new firm formation as well as on the growth of incumbent firms, while competition only has a positive effect on new firm formation. It is especially the effects of industrial diversity that are revealed to be sensitive to urban contexts: positive effects on new firm formation are attached to the connected cities and to the highly urbanized Randstad, and positive effects on firm growth to the intermediate zone, the connected cities and urban municipalities.

1. Introduction

The role of agglomeration economies in the formation of new manufacturing firms has been studied in urban economic literature, examining the so-called "incubator hypothesis" (Hoover and Vernon, 1959; Leone and Struyk, 1976; Fagg, 1980). Recent studies have shown the value of agglomeration economies in explaining differences in the entry rates of high-tech firms (Rosenthal and Strange, 2003; Stuart and Sorenson, 2003). This relates to the endogenous growth theory as formulated by Romer (1986) and Lucas (1988), which states that investment in knowledge is likely to be associated with spillovers to other agents in the economy. These knowledge spillovers, an important source of agglomeration economies (Marshall, 1920), play a fundamental role in determining the rate of technological progress. As such, the efficiency of transmitting knowledge on to economic applications is seen as a crucial factor in explaining economic growth. These spillovers from knowledge institutions or high-tech firms are subject to geographic constraints, especially when they relate to relatively new (tacit) knowledge (Howells, 2002). Most studies on spatial externalities focus on overall employment growth (see e.g. Le Blanc, 2004). As a consequence they do not consider the role of spatial externalities on some employment growth components: growth caused either by new firm formation or by growth of incumbent firms. These two components reflect distinct phases in the life cycle of firms, which are likely to be differentially affected by knowledge spillovers and have different effects on economic growth.

This paper examines the way agglomeration economies, indicators of knowledge spillovers, affect the formation of new firms as well as growth of incumbent firms in the Dutch ICT industry. There have been a many policies that were meant to support entrepreneurship, both in general and in specific industries related to information and communication technology (ICT), to stimulate the diffusion of information and communication technology to business (OECD, 2005) and in the end to enhance economic performance (Audretsch and Keilbach, 2004). In addition to its policy relevance, the ICT industry is also relevant to the debate on knowledge spillovers and economic growth. Whereas studies like Glaeser *et al.* (1992) have focused on relatively mature industries, our study focuses on the relatively young ICT industry. Geographic proximity matters most in industries where tacit knowledge plays an important role in the generation of innovative activity (Acs, 2002), and tacit knowledge plays the most important role in the early stages of the industry life cycle (Audretsch and Feldman, 1995). Hence, geographically bounded knowledge spillovers are likely to be more important in an industry that is in an early stage of its life cycle, like the ICT industry.

The spatial, longitudinal and sector-related detail of the data allows for a more sophisticated testing of these questions than previous studies. The data provide counts (relative to the population) of new and incumbent firms and their employment levels per industry in 580 Dutch municipalities over a five-year period extending from 1996 to 2000. The approach taken closely resembles the one adopted by Rosenthal and Strange (2003), who analysed the determinants of firm births in United States zip codes using Dun & Bradstreet Marketplace data. While the US data have the advantage that more information is available about each firm, the Dutch data provide information about all firm births and growth. For example, in the study conducted by Henderson *et al.* (1995), the strategy of analysing all the cities within a given industry presented many problems. As a result of disclosure rules, employment data for as many as 30% of cities were censored. The data set is the result of a longitudinal survey on employment in all ICT firms in the Netherlands; we therefore expected it to provide a clearer picture of the spatial characteristics of areas that affect new firm formation and the growth of incumbent firms.

This paper focuses on three central questions. First of all, we wanted to determine what measurable agglomeration factors are connected to new firm formation and the growth of incumbent firms in the Dutch ICT industry. Secondly, our analysis looks at the conceptual spatial configurations that best describe the patterns of the formation of new firm and growth of incumbent firms. We asked ourselves what additional role is played by spatial regimes (such as urban hierarchy, labour market areas, national core-periphery distinctions) in conjunction with the localized proximity-thesis stressed in relevant literature. Finally, we focus on the question whether entrepreneurship as measured by the *growth* of incumbent firms in the young ICT industry is related in a different way to spatial externalities than new firm formation rates in this industry.

The remainder of the paper consists of four sections. Section 2 provides the background for the agglomeration and entrepreneurship hypotheses tested in the analysis. Section 3 (on the research design) provides a detailed description of the dataset, the spatial regimes (urban contexts) and the agglomeration indicators. Section 4 presents econometric analyses of the relationship between agglomeration indicators and new firm formation and the growth of incumbents. In section 5 we present and discuss the overall conclusion.

2. Entrepreneurship and agglomeration economies: a literature review

2.1 The geography of entrepreneurship

This section addresses the broad definitions of entrepreneurship generally used in existing literature, and links them to agglomeration economies. Although entrepreneurship has traditionally been defined as the formation of new firms, some scholars argue that entrepreneurship transcends start-up activities, also manifesting itself as firm growth (Merz et al, 1994; Davidsson et al, 2002; Hart, 2003). Our paper focuses on this question, by comparing new firm formation and the growth of incumbent firms in the young and dynamic ICT industry.

Although in the second half of the twentieth century the role of the entrepreneur had been rather neglected in mainstream economics, it has acquired a central importance in the recently emerging multidisciplinary field of 'entrepreneurship studies', which contribute to the understanding of the uniqueness of entrepreneurship, something that cannot be understood within the framework of existing scientific disciplines (Sexton and Landström, 2000). Entrepreneurship studies used to focus on the traits and characteristics of the autonomous entrepreneurial actor (Gartner, 1989), an approach that is sometimes called the 'omnipotent, lone wolf' view on entrepreneurship. Until recently, this supply-side perspective, which focuses on the assumed specific traits of entrepreneurs and the availability of suitable individuals to occupy entrepreneurial roles was the dominant school of research (Thornton, 1999). During the 1980s, research gradually moved away from the 'lone wolf' view towards a 'relationship manager' view of the successful entrepreneur (Davidsson, 2002; Nijkamp, 2003). Several studies have redirected the focus away from the individual towards the entrepreneurial process or event, i.e. the creation of a new firm (Gartner, 1989). There is an emerging consensus on what the distinctive entrepreneurial processes are: opportunity recognition, resource acquisition, resource generation, and coordination of resources (Garnsey, 1998). The current scientific object studied in entrepreneurship studies is “the dialogic between an individual [the entrepreneur] and new value creation within an ongoing process and within an environment that has specific characteristics” (Bruyat and Julien, 2000, p. 165). In short, entrepreneurship studies show a marked shift towards an interactive perspective, focusing on the interaction between entrepreneur and context (cf. Appold, 2001; Feldman, 2001). Studies that take this approach focus on the context in which entrepreneurs operate. We would argue that especially the spatial aspects of the entrepreneurial context have to be analysed, as entrepreneurship is influenced by regional characteristics, and in turn affects regional economies. Entrepreneurship can be defined as the process whereby entrepreneurial opportunities – opportunities to produce new goods, services, markets, supply sources, and organizing methods – are recognized, and realized in a profitable way., a definition that is based on both Schumpeterian innovations and on an Austrian economics’ view on opportunity recognition. Although to a large extent the early growth of new firms is a reflection of entrepreneurship, there is a difference between entrepreneurship as expressed in new firm formation and entrepreneurship as defined as firm growth. The former phenomenon can be explained largely by environmental and personal factors, while the latter is better explained by referring to (other) environmental and firm-internal factors, such as human resources. To explain the (spatial) patterns the formation and growth of firms, we need to understand what mechanisms are necessary for these two types of entrepreneurial outcomes. These mechanisms may be affected by the geographical proximity or ecological characteristics of spatial units (localities, regions, and countries).

New firms are likely to be created in areas where there are many individuals that are willing to take the risk of starting up a new business, as well as a sufficient supply of resources. These resources can be provided by the individuals’ social relations (‘family, friends, and fools’) or through more formal market relations (banks, suppliers of inputs) (cf. Feldman, 2001; Audretsch and Keilbach, 2004). Sørenson and Sorenson (2003) argue that there is a basic set of two sources that explain variations across regions in the rates of new firm formation: (1) variation in the regional rate of entry attempts; and (2) regional variation in the ability on the part of potential entrepreneurs to mobilize resources. The first source is likely to be driven by the (spatial) distribution of opportunities and variation in the perception of opportunities. The recognition of an opportunity is the primary mechanism for the start of a new business. However, when an entrepreneur recognizes an opportunity, he or she needs to have access to sufficient resources to capitalize on the opportunity. Other resources most likely have to be acquired externally and/or created internally. According to the ’incubator hypothesis’, it is easier to mobilize resources in urban areas: “persons aspiring to go into production on a small scale have found themselves less obviously barred by a high cost structure at the centre of the urban area than at the periphery” (Hoover and Vernon, 1959, p. 47). Leone and Struyk (1976) restated the incubator hypothesis as: “small manufacturing companies beginning operations will find it to their comparative advantage to locate at highly centralized locations within the metropolis”. This advantage derives mainly from the availability of production space that can be leased (land costs may be high, but property costs are relatively low; see Fagg, 1980), inputs, labour and other services at central urban locations, but also from lower supply risks and good communication with customers and suppliers. In short, the explanatory framework was primarily that of static urbanization economies.

Several mechanisms are necessary for the growth of young firms in relatively new industries, like the ICT industry (Stam, 2003). After it has been set up, a firm has to survive in a market environment. To reach economic viability it has to generate resources in a specific product-market. The subsequent growth can be realized when the demand in this initial product-market increases (without an increase competition) or when new opportunities are recognized and realized in new product-markets. Growth also requires managerial skills in deploying the resources required in an effective and efficient way. These are processes that do not take place in a vacuum. The characteristics of the (input and output) markets and networks in which firms operate need to be taken into account when we want to explain their creation and growth.

To explain the spatial pattern of new firm formation and firm growth, we need to determine how important the spatial aspect of these processes are, whether in networks (of resource providers or co-producers) or in product-markets. Various propositions can be formulated to describe growth in the ICT industry. The location of a new firm is determined by where it sees an opportunity. However, the recognition of an opportunity is the product of both the experience and imagination of the entrepreneur(s) and the nature of the environment in which the firm operates. Individuals working and living in (ICT) industry centres are more likely to have the (industry) experience needed to recognize new opportunities. Information-rich (urban) environments may also make it more likely that opportunities will be spotted. The access to resources is probably affected by their spatial distribution. Areas where there is a relative abundance of resources may make it easier for firms to acquire the resources they need directly (on markets) or indirectly (via network connections). However, two 'intervening' effects must also be taken into account. Firstly, once proximity benefits have dissipated resources may be equally available in other areas as well and internal learning trajectories (e.g. via R&D) become more important over the years. Secondly, competition may make it harder for a firm to obtain the necessary resources in an area where there is an abundance of resources than an environment where there are fewer resources, but where there is also a less fierce competition. The resource generation process may be stimulated by concentrations of consumers of ICT-products, again controlling for competition in those areas and taking into account the importance of proximity. Finally, a factor that applies to firm growth specifically is the presence of managerial talent and skilled labour within the region, once more taking into account the level of competition, but assuming that this type of labour is to a large extent region-bound.

There are a number of important agglomeration factors that we want to hypothesize and test empirically. What are the sources of knowledge spillovers: do they take place within a specific sector (reflected in R&D-spillovers of more mature firms or localized specializations) or between sectors (reflected by industrial variety)? What is the role of competition between ICT-firms? Are the two entrepreneurial phases in the firm life cycle - new firm formation and the growth of incumbent firms – affected by agglomeration economies in a similar way? And finally, what are the spatial scales or urbanization regimes that are important to new and incumbent ICT-firms attempting to benefit from agglomeration economies?

2.2 Agglomeration hypotheses

In this section we list the agglomeration indicators that we use to determine the relationship between agglomeration economies and entrepreneurship leading to new firm formation and firm growth in the ICT-industry. The concepts of local specialization, industrial variety and local competition are translated into indicators for agglomeration economies. Empirical tests of agglomeration economies have often looked at cities to identify settings in which these external factors foster employment growth most effectively. The frequently used 'simple incubator hypothesis', therefore, limits itself to stating that more densely populated urban regions produce higher levels of entrepreneurship and hence greater employment growth (Brakman *et al.*, 2001; Fujita and Thisse, 2002). Recent research aiming at disentangling agglomeration factors in urbanization and localization economies, however, is divided. On the one hand, Glaeser *et al.* (1992) and Feldman and Audretsch (1999) find that employment growth and firm dynamics are enhanced by a diversity of activities across a broad range of industries. Henderson *et al.* (1995), Black and Henderson (1999), and Beardsell and Henderson (1999), on the other hand, argue that growth is faster when a higher proportion of business activities is concentrated within a single industry (specialization). Although the positive effect of competition on growth has been regarded as a stylized fact, it is still not clear how we ought to interpret that fact (Glaeser 2000, p. 93). While endogenous growth theory is among the most powerful advances in economics in the last decades, the fact that it is as yet unclear to what situations it best applies and how the effects can be interpreted represents a barrier to its further development and application. The lack of agreement on the relative importance of industrial concentration, diversity and their spatial composition sends an ambiguous message with regard to which policies have the best chance of promoting economic growth in urban areas (Parr, 2002; Rosenthal and Strange, 2001).

As indicated earlier, the determinants of technological change have been the subject of further theorizing in endogenous growth theory, which has resulted in new growth models. In addition to learning opportunities related to localized specialization, diversity and competition structures in dense urban areas, these models include education, research & development (R&D) or learning-by-doing as additional inputs affecting growth. Firm-internal (rather than mainly geographical, external) knowledge has come to be seen as an endogenous core input for economic growth as well, and associated economies of scale or scope have been included under the heading of 'knowledge economies'. Recent debates in economic growth theory have shifted away from material towards immaterial inputs, and in particular to the positive externalities that arise from knowledge spillovers (Jaffe, 1986; Griliches, 1992), and as spillovers imply the possibility of under-investment in knowledge (in light of the danger of knowledge leaking to competitors), government policy has increasingly focused on providing subsidies for R&D and stimulating university-industry cooperation. These additional spillover hypotheses can only partly be applied to the Dutch ICT industry, as especially SMEs in the Dutch ICT industry hardly interact with universities (Wever and Stam, 1999). However, we will also test for the effect of localized R&D-expenditures.

In this paper we test theories of (dynamic) spatial externalities at the city (municipal) level. Several hypotheses have been proposed to describe the conditions under which knowledge spillovers affect growth (see also Glaeser *et al.*, 1992, p. 1127-1132). One hypothesis, originally developed by Marshall (1920) and later formalized by Arrow (1962) and Romer (1986) (collectively called 'MAR'), argues that knowledge is predominantly industry-specific and hence local specialization will foster entrepreneurship, leading to new firm formation and firm growth in the ICT-industry. The theory of Marshallian externalities states that intra-industry knowledge spillovers occur alongside agglomeration effects due to labour market pooling and input sharing (see for recent elaborations Feser (2002) and Rosenthal and Strange (2001), and, for an application to computing services, Fingleton *et al.* (2004)). This closely resembles the concept of localization economies (cf. Malmberg and Maskell, 2002). Furthermore, (local) market power is also thought to stimulate firm growth as it allows the innovating firm to internalize a substantial part of the rents. Although the second hypothesis, proposed by Porter (1990), also states that knowledge is predominantly industry-specific, it argues that the effects on growth are enhanced by local competition rather than market power, as it forces companies to be innovative if they want to survive. A high level of competition is likely to lower the entry barriers for new firms. The third hypothesis, proposed by Jacobs (1969), agrees with Porter that competition fosters growth, but it also contends that regional diversity in economic activity will result in higher growth rates, as many ideas developed by one industry can also be fruitfully applied to other industries. Table 1 summarises the spatial externalities distinguished in these respective hypotheses.

Table 1. Stylised and hypothesised relations of inter-and intra-industry agglomeration circumstances with economic growth

	MAR	Porter	Jacobs
Concentration	+	+	–
Diversity	–	–	+
Competition	–	+	+

In this paper, we examine the empirical relationship between these hypotheses and the spatial patterns of new firm formation and growth of incumbent firms in the Dutch ICT industry. Although there has been research into the effect of clustering on new firm formation and firm growth in the ICT industry (see e.g. Coe and Townsend, 1998; Bresnahan *et al.*, 2001), it is still unknown whether distinct agglomeration elements, like local specialization, industrial variety, and local competition, affect the formation and/or growth of firms in the ICT industry. Some controversies regarding the effect of specialization on firm growth emerge from literature: Baptista and Swann (1999) and Fingleton *et al.* (2004) found a positive effect in US and UK computer industries and computing services in Great-Britain; Globerman *et al.* (2005) found that firm growth in the Canadian IT industry is enhanced by *both* diversity and specialization; and other studies found a positive effect on entry rates but a negative effect on firm performance in the US footwear and biotechnology industries (Sorenson and Audia, 2000; Stuart and Sorenson, 2003). According to Friedman (1995) there is a positive correlation between industrial diversity and small firm growth in urbanized areas in the USA. New firm formation and firm growth are likely to be related in different ways to agglomeration indicators that reflect urbanization (diversity), localization (specialization) and competition. Incumbent firms may also be more sensitive to firm – or sector – internal learning strategies like R&D. We will test for this in the empirical part of this paper.

3. Research design: data, spatial regimes and agglomeration indicators

3.1 Data: ICT establishments in the Netherlands 1996-2000

Although ICT is used in almost all sectors of the economy, we have limited our research to ICT-providing firms, which include services industries. These high-tech firms are relatively footloose (little sunk-costs in terms of capital) and depend on (localized) learning opportunities with customers, suppliers and competitors. We focus on 22 ICT industries (see table 2).

Table 2. Employment in the ICT industries in the Netherlands (average 1996-2000)

Industry	No. of jobs	% of jobs
Manufacturing:		
Production of hardware	9,154	4,7
Production of software	46,196	24,1
Trade:		
Wholesale trade of ICT products	27,603	14,4
Retail trade of ICT products	4,443	2,3
Services:		
Internet/(multi)media, telecom	35,722	18,7
Data- and computer centres	10,701	5,6
ICT Consultancy	54,498	28,5
Other kinds of (ICT) producer services	3,149	1,6
Total	191.466	100

Earlier research has shown that high-tech manufacturing in the Netherlands is dominated by a few large corporations (Van Oort, 2004). Trade and services, which make up some 70% of the research population, are not affected by firm size. These preliminary remarks are important, since it has an impact on the research outcome, both theoretically and technically (through the spatial competition indicator that also captures relative firm size, see section 3.3). As we explain in section 4, formal testing will be conducted at the aggregated sector scale, because there is insufficient spatial dependency in growth rates either in individual industries or in the three broad sectors of ‘manufacturing’, ‘trade’ and ‘services’ presented in table 2. Employment growth in new and incumbent firms in the ICT industry are therefore measured by employment dynamics generated by all ICT industries.

The population of ICT firms was collected in a two-step procedure. In the first step we screened the Yellow Pages for all regions in the Netherlands for firms from the following business categories: software, automation, Internet, tele- and data communication, which yielded a population of 12,878 ICT firms. As the Yellow Pages do not contain information on every existing firm and on existing employment levels, we completed the dataset in a second step, in which the data we obtained from the Yellow Pages was linked to the nationally covered LISA file, which registers the employment of over 750,000 firms and institutions in the Netherlands on an annual basis. We compared the two files and added firms we found only in the LISA file to the Yellow Pages file, an exercise that resulted in an average total population of 18,985 firms between 1996 and 2000. The number of jobs in ICT firms represents nearly 4% of overall employment, which indicates that ICT is still a relatively small industry in the Netherlands. Furthermore, it became clear that employment in the Dutch ICT industry is dominated by service activities like consultancy, Internet provision and wholesale trade. Within the field of manufacturing it is the production of software that dominates (Weterings and Van Oort, 2004). Unfortunately, we were unable to distinguish branches from independent firms and could thus not ‘control’ for intra-firm transfers of knowledge in multilocational firms.

Several additional alterations to the data were carried out for this paper. Concentration and specialization indicators are calculated as average over the years 1996-2000. Growth indicators compare the average stock of firms over 1996 and 1997 with the average stock of firms over 1999-2000 in order to minimize (spatial or temporal) outlier dependency. Growth rates are calculated for the population of all the incumbent firms (present in 1996 and eventually later years). We measured the other explained variable in our models, new firm formation, as the annual average number of ICT start-ups as a proportion of all existing firms in the base year per municipality in the Netherlands (n=580) in the period 1996-2000. We explicitly wanted to test for this life-cycle aspect in the (relatively young and dynamic) ICT industry. Furthermore, the firm level data are aggregated into 580 locations that represent municipalities. The four largest municipalities (Amsterdam, Rotterdam, The Hague and Utrecht) are split into 3-digit zip code areas to allow us to distinguish harbours, central locations and edge-city locations within municipalities (still referred to as municipalities). The longitudinal, firm level database allows for a distinction between new and incumbent firms.

3.2 Spatial regimes in the Netherlands

It is often argued that urbanization levels have a strong influence on the number of new firms and their (subsequent) growth. This section classifies urbanization levels in the Netherlands along three spatial scales. Most of the relevant empirical literature focuses on American states as the spatial unit of analysis. Some studies, however, focus on lower scales of analysis. Anselin *et al.* (2000), Black (2004) and Wallsten (2001), for instance, use metropolitan statistical areas to analyse the spatial extent of R&D and growth externalities and find that local spatial externalities exist and are important. Our empirical analyses explore a non-American context, and we take into account spatial regimes that were excluded from prior studies into agglomeration economies.

Existing (geographic) literature provides clues for non-contiguous (regime) types of spatial dependence. Quality of life aspects, regional labour markets, specialized networks and city size are considered significant location-related considerations, both to professional workers and to growing ICT firms (Van Oort *et al.*, 2003). The spatial structures of proximity (contiguous nearness at the municipal level) and heterogeneity (urban hierarchical and regional, not necessarily contiguous, spatial dependence) have been tested for in this study and whenever appropriate been controlled for by spatial dependence (spatial lag and spatial error) specifications and spatial regimes respectively. Where it was appropriate, the spatial coefficient in spatial lag estimation shows whether the dependent variable in a model (in our case localized firm growth and new firm formation rates) is dependent on neighbouring values of this dependent variable. If so, conclusions can be reached on the significance and magnitude of this spatial dependence (Anselin, 1988). Spatial heterogeneity, on the other hand, is modelled by spatial regimes, involving change-of-slope regression estimation over various types of locations that theoretically ‘perform’ differently. Three sets of spatial regimes in all are distinguished, each indicating aspects of urban structures at different spatial scales:

(1) At the macro-level, three national zoning regimes have been distinguished: the Randstad core region, the so-called intermediate zone and the national periphery (figure 1). The division into macro-economic zones in the Netherlands is based on a gravity model of total employment concerning data from 1997. The Randstad region historically comprises the economic core provinces of Noord-Holland, Zuid-Holland and Utrecht, the intermediate zone mainly comprises the growth regions of Gelderland and Noord-Brabant, while the national periphery consists of the northern and southern regions of the country. This zoning distinction is considered important in many studies on endogenous growth in the Netherlands, in the sense that the Randstad region traditionally has better economic development potential (cf. Van Oort, 2004).

(2) At the intermediate level we distinguish a labour market-induced connected regime from a non-connected regime (figure 2). This spatial regime concerns commuting-based labour market relations. In figure 2, core and suburban municipalities together comprise the connected regime, as opposed to the other types of locations that are characterized as non-connected. The four types of locations that have been distinguished were initially based on municipal data for 1990-1999. The classification is based on the extent to which a municipality's population depends on the proximity and accessibility of employment and services. Urban core areas have an important employment function. More than 15,000 persons commute to these areas (while living somewhere else) on a daily basis. Municipalities where more than 20% of residents commute to central core locations are labelled suburban. Empirical studies have found that urban areas in the connected regime show higher innovation rates and economic growth than areas in the non-connected regime (e.g. Anselin et al, 2000). As becomes clear from figure 2, locations in the connected regime are not necessarily adjacent to each other.

(3) The third set of spatial regimes is constructed using the level of urbanization of municipalities (figure 3). Following Dutch standards of urbanization, cut-off population thresholds of 200,000 and 45,000 inhabitants distinguish large and medium-sized cities in the Netherlands from small cities. To allow for a comparison with international studies, we have divided the municipalities into urban municipalities (the large and medium-sized cities) and non-urban ones (the small cities) respectively.

To summarize, these three aspects of spatial heterogeneity constitute three spatial levels of urban constellation: the intermediate level 'agglomerative fields' of the Randstad core region compared to its adjacent intermediate zone and the national periphery, the functional (commuting) region, and the urban level itself.

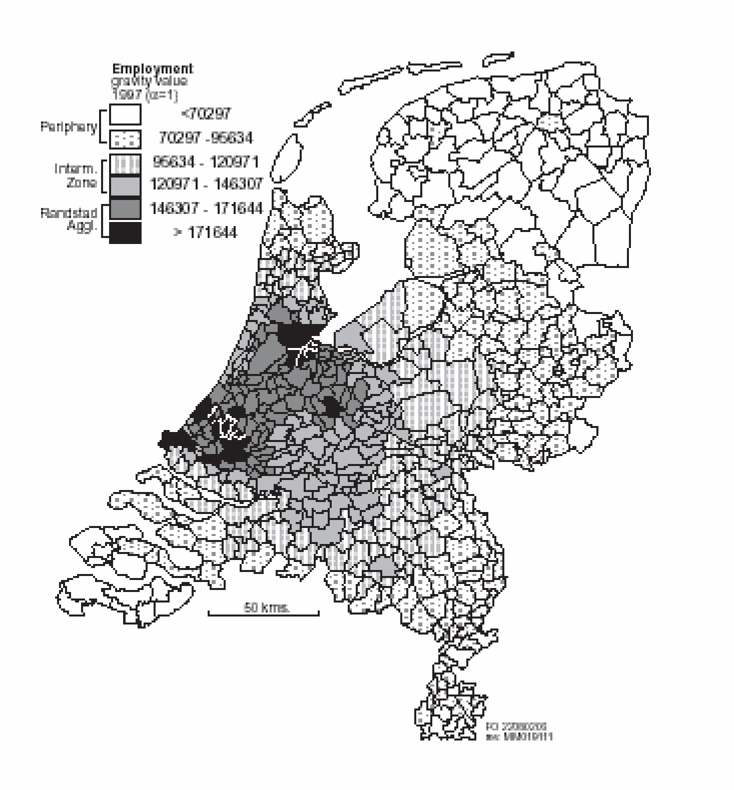

Figure 1. National zoning spatial regimes

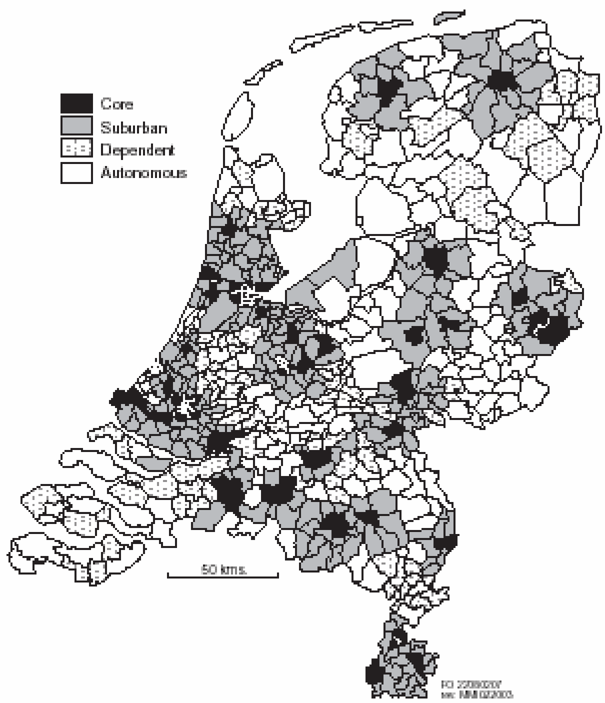

Figure 2. The (labour market) connectedness spatial regimes

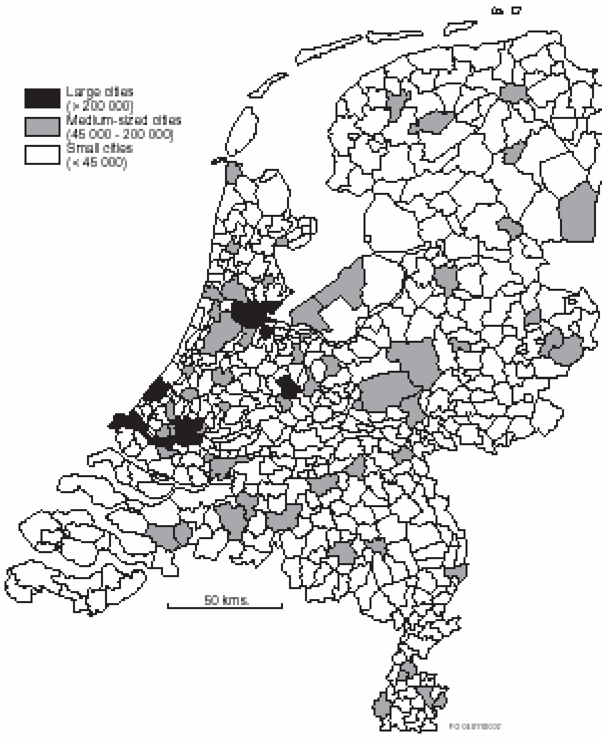

Figure 3. Urban size (municipal) spatial regimes

3.3 Agglomeration indicators

The relatively small size of the Netherlands provides a natural control for much location-specific heterogeneity. In fact, several variables described in related studies (Henderson *et al.*, 1995; Cortright and Mayer, 2001; Glaeser, 1999) as potentially important location-specific factors affecting either employment growth or firm birth rates – are either roughly constant between locations in the Netherlands, or else they can at least be partially controlled. Cultural differences as well as variations in taxes, environmental amenities (such as climate) and environmental regulations are small. There is little variation across the country in the price of resources other than the cost of land. Although energy prices may vary from industry to industry, as a rule they are roughly the same for firms that operate within the same industry. The same can be said with regard to wage levels. Thus, wage rates within an industry would be uniform and there is little need to control for labour force characteristics such as the level of education, proportion of workers with particular skills, or the percentage of workers with union membership (see Van Oort (2004) for actual testing of these elements).

We used municipal employment figures that presented the data on an industry-specific basis to construct indicators of various types of agglomeration economies (as hypothesized in section 2.2) that are as reminiscent as possible to those used in prior studies (see especially Glaeser *et al.* (1992) and Henderson *et al.* (1995)). The agglomeration indicators are not constructed relative to the ICT-database itself but relative to a national data set which includes all industries, both for technical reasons (multi-collinearity) and for theoretical reasons (agglomeration economies are commonly defined in a national, aggregated setting). As we wanted to test whether initial spatial circumstances are connected to new firm formation and incumbent firm growth (a 'sources of growth' analysis; cf. Glaeser *et al.*, 1992), explanatory variables were constructed using data from the base year (1996) to reduce problems of simultaneity. *CONCENTRATION* is defined as a location quotient showing the percentage of employment accounted for by an industry in a given municipality relative to the percentage of employment accounted for by that industry in the Netherlands. This indicator in particular comprises (industry-specific) localization or specialization economies[2]. *COMPETITION* is measured as firms per worker in a municipality and industry divided by firms per worker in that industry at the national level. This measure indicates whether firms in industries tend to be larger or smaller in a municipality compared to the country as a whole. This spatial indicator of relative firm size fits in a tradition of identifying common labour market competition and market structure indicators. Glaeser *et al.* (1992) interpret this variable as a measure of local competition on the assumption that competition is more intense when there is a larger number of smaller firms than when there is a smaller number of larger firms. This interpretation, however, has been called into question by Combes (2000), who contends that it may measure internal diseconomies of scale, and by Rosenthal and Strange (2003), who view it as a broader measure of local industrial organization. For reasons of consistency, i.e. optimal comparison with the Glaeser *et al.* (1992) and Henderson *et al.* (1995), we have applied the relative firm size definition of localized competition. Several variables were tried as a measure of industrial diversity to indicate how evenly employment is distributed across economic sectors within a given municipality. *NON-DIVERSITY,* the Gini-coefficient for the distribution of employment by industry in a municipality, measures the absence of diversity. The locational Gini-coefficient has a value of zero if employment shares among industries are distributed identically to that of total employment in the reference region (across 49 industries in the Netherlands, of which the ICT industry represents only a minor part). A value of 0.5 results if employment is concentrated in only one industry. Lower values of the Gini-coefficient thus indicate higher degrees of diversity. The diversity indicator is treated as indicator of urbanization (not industry specific) economies. Results presented in the next section can be used to make at least a suggestive test of the three sets of agglomeration hypotheses (see table 1)[3]. Based on R&D-indicators presented in Van Oort (2002), who used the same spatial level of analysis applied in this paper, we also controlled for the influence of (local scores of) R&D-intensity (*R&D INTENSITY*) on new firm formation and the growth of incumbents in the ICT industry.

4. Agglomeration economies and entrepreneurship in different spatial regimes

In this section we will focus on the effect of agglomeration economies on new firm formation and incumbent firm growth, in different spatial regimes. The econometric models that we tested for are summarized in tables 3 and 4. Only the most parsimonious research results are presented. Below the tables, technical explanation on the models is provided. The degree of concentration, (non-)diversity and competition are introduced according to the definitions presented in sections

2.2 and 3.3. In addition to concentration indices of ICT firms, similar indices for manufacturing and business service activities are also introduced in the model. Likewise, in line with the Glaeser *et al.* (1992) approach, competition is measured by relative firm size both for ICT firms and for all manufacturing and all business service firms in localities in an aggregated sense.

The Ordinary Least Squares model for new firm formation (column (1) of table 3) shows the significance of the two concentration indicators (of the 'own' ICT industry, as well as in general for business services in a positive sense) and the diversity indicator. The third agglomeration indicator, which measures localized competition circumstances in the ICT industry, shows a positive relationship when measured for the 'own' ICT industry. However, this indicator shows a negative relationship when measured in general terms (especially with business services). Interestingly, these results do not provide unambiguous support for any of the three endogenous development theories discussed in section 2. The variable on R&D-intensity of economic activities (*R&D INTENSITY*) shows no significant relationship with new firm formation in the ICT industry. This indicates that spatial externalities related to urban density represent a bigger source of new firm formation than do innovation investments of firms.

Although the results for own (ICT) industry specialization support the MAR and Porter hypotheses, those for diversity support Jacobs´ hypothesis. Results for (own, ICT) levels of localized competition support Porter and Jacob's hypotheses of growth, but not the MAR hypothesis. The general concentration indicators stress the importance of business service specialization for new firm formation in the ICT industry (which predominantly consists of firms offering business services).

The results presented are of interest from the broader perspective of those concerned with the location tendencies of new firms in the ICT industry connected to agglomeration-related circumstances. New ICT firms tend to cluster in municipalities that already are ICT employment centres, with a high level of competition in the ICT industry, and a richness in diversity. This may be explained on the grounds that individuals working in small ICT firms want to become, one day, entrepreneurs in the ICT industry themselves. This seems especially the case in areas where the entry barriers to starting a firm in the ICT industry are relatively low and relatively many opportunities from other industries can be pursued.

The test statistics of LM(ρ) and LM(λ) in Column (1) reveal the presence of spatial autocorrelation dependency of the model. In columns (2)-(5) of table 3, therefore, the models are estimated including a spatial lag specification, columns (3) – (5) additionally specified with spatial regime estimation. Except for model (2) without the spatial regime estimation, the Lagrange multiplier tests on spurious spatial error dependence indicate that the models deal adequately with spatial (proximate) dependence by incorporating the spatial lag term. The spatial weight matrix used (W_1) for this contains inverse distance spatial weights between all 580 municipalities. Several other definitions were tested (using inverse distance powers 2 and 3) but they performed less well. Although heteroscedasticity emerges as a problem in the original OLS-model (1) (see the LM(BP) statistics), the spatial regime estimates do solve this problem (the spatial regimes adequately capture the causes of residual-divergence or heteroscedasticity). Columns (3a-c), (4a-b) and (5a-b) present maximum likelihood estimations, allowing for a structural change of coefficient estimates between spatial regimes. In certain spatial regimes related to urbanization there appears to be a significant spatial dependence in the formation of ICT-firms. Table 3 shows in columns (3), (4) and (5) that the concentration indicators work out more favourably for new firm formation in urban municipalities than for non-urban ones and in (commuting) connected locations rather than unconnected locations. The spatial Chow-Wald tests for these models confirm the significance of the connectedness and urban regimes at the 5% significance level. The model fit improves significantly for the connectedness and urban regime models when compared to the original OLS and spatial models without the urbanization regimes (models (1) and (2)). The national zoning regimes (model (3)) do not capture any significant change-of-slope regional divergence of new firm formation in Dutch municipalities. Connected spatial regimes (comprising central cities and their suburban municipalities) and larger urban municipalities are significantly better attached to the agglomeration indicators. These locations are characterized by a positive link of diversity and the concentration of ICT firms on the formation of new ICT firms.

In table 4 the analysis is repeated for the population of *incumbent* ICT firms only (those firms that existed during the complete survey period 1996-2000). The OLS model in column (1) shows differences with the new firm formation analysis. Industrial variety and own-sector specialization are again significantly attached to incumbent firm growth. However, the concentration of business services and local ICT firm competition has no significant effect on incumbent firm growth, in contrast to the positive effect of this indicator on new firm formation. Growth of incumbent ICT firms seems unaffected by local competition. A spatial-lag or -error formulation appears to improve the model, because the LM(ρ) and LM(λ) statistics in column (1) do not indicate spurious signs of spatial dependence with the most important variables introduced. These variables capture the spatial autocorrelation significantly; the model does not gain from further autocorrelation-specifications. Some more remarkable differences with the new firms analysis becomes clear. At the 10% significance level, the Randstad-intermediate zone-national periphery regimes become significant. The intermediate zone has characteristics that are positively linked to growth in incumbent ICT firms, especially the significant additional correlation of R&D intensity of firms in the intermediate zone sets the incumbent growth model apart from the new firms model. This positive effect of R&D intensity can also be found in the connected regime. Localized R&D-intensity can be interpreted as an additional source for learning externalities of incumbent ICT firms in at least two spatial regimes. At a lower spatial level, the municipal urban regimes (column (4) in table 4) do not contribute significantly to the description of spatial variation in the growth of incumbent firms.

Table 3 / Table 4 ABOUT HERE

In general, we can conclude that the relationships we found work have the most profound impact in urban environments defined by individual municipal size and by the size of urban regions, including the central cities' suburbs. This confirms the urban setting of the endogenous growth theories as outlined in section 2. But different definitions of urbanization appear to be significant for new firm formation and the growth of incumbent ICT-firms. Column (2) in table 4 shows that the intermediate zone most notably 'exhibits' the significant set of agglomeration economies for incumbent firms, as opposed to the national periphery and (to a lesser extent) the Randstad. The model fit is better than in the original OLS model.

Both the incumbent and the new firm analyses show the significance of the connected spatial regime, as opposed to the unconnected regime. Given the relatively poor fit of the indicators of the incumbent growth models (see also Hoogstra and Van Dijk, 2004) compared to the new firm models (as measured by the improvement of the maximum estimated likelihood in the new firm models and the R^2 in the incumbent growth models), spatial externalities seem to be more relevant in explaining the spatial variations in the latter. Incumbent firms are likely to have a wider spatial orientation than new firms. This also seems to be confirmed by the insignificance of the spatial lag specifications of the growth models and the fact that for the growth models the spatially broader macro-zoning regimes are important while for the new firm models the spatially narrower urban regime is important. The analyses show that urbanization has an important impact on new firm formation and the growth of incumbent firms on different scales of urban analyses in the Netherlands, both defined by contiguous proximity (captured by the spatial variation of the explanatory variables in the econometric models and spatial lag estimations) and by the spatial heterogeneous regimes. This extends the current debate on spatial externalities considerably, which focuses almost exclusively on proximity based spillovers and knowledge transfer.

5. Conclusions

In this paper we have focused on three central questions. Firstly, we wanted to determine what measurable agglomeration factors are connected to new firm formation and incumbent firm growth in the ICT industry in the Netherlands. Secondly, our analysis focused on the conceptual spatial configurations that best describe patterns of new firm formation and the growth of incumbent firms. We asked ourselves what additional role network-based spatial regimes (such as urban hierarchy, labour market areas, national core-periphery distinctions) play compared to the localized proximity-thesis stressed in the literature. In turn we applied our approach to the hypothesis that large cities or urban regions are breeding grounds for entrepreneurship because of localized knowledge spillovers. Thirdly, we focused on the question whether entrepreneurship as measured by the growth of firms is related differently to spatial externalities than new firm formation rates in the young and dynamic ICT industry. In this section we answer these questions according to the research outcomes presented in the previous sections and draw conclusions.

Our answer to the first question – which measurable agglomeration factors are connected to new firm formation and incumbent firm growth in the ICT industry in the Netherlands – is not as straightforward as might be expected from the current scientific debate (which stresses either localization or urbanization economies). In contrast to new firm formation, incumbent firm growth is not affected positively by ICT firm competition. The effects of the diversity and concentration measures are positively related to incumbent firm growth, just as with new firm formation in the ICT industry. These outcomes neither fully support, nor do they fully contradict the theories of knowledge spillovers, attributed to Marshall-Arrow-Romer, Porter, and Jacobs. As indicated, the determinants of technological change have become subject of further theorizing in endogenous growth theory, giving rise to new growth models. These models also include R&D as an important additional input affecting growth. It turned out that localized R&D-

intensity as an additional source of learning externalities is attached to incumbent firm growth in two dominating urban regimes (in the intermediate zone and in the connected municipalities). In general, R&D-levels are not related significantly to incumbent firm growth and new firm formation.

The elements for answering the second research question - what spatial configuration describes the new firm formation and incumbent firm growth patterns best - come from econometric analyses. Especially the insignificance of spatial lag estimators in the incumbent firm growth models presented in section 4 indicate that, unlike with new firm formation, incumbent firm growth in the Dutch ICT industry is not related significantly to proximity and contiguity-based spatial autocorrelation. At the same time, the change-of-slope econometric analyses of section 4 show that urbanization defined in spatial heterogeneous (non-contiguous) regimes affect incumbent firm growth and for new firm formation differently on various spatial scales of analysis in the Netherlands. At a regional level, firms in the so-called intermediate zone outperform firms in the national core region, the Randstad. These cities and regions, although significantly smaller in size, are characterized by positive links of concentration of ICT firms, diversity, and R&D intensity with growth of incumbent firms. These results are particularly interesting, because earlier studies on economic dynamics (specifically ICT firm dynamics) did not focus on these regimes.

When we look at our third and final question, we see that most studies of location determinants emphasize employment growth in general and on innovation intensity. Relatively few studies have looked at the components of employment growth arising from firm births and growth. The relative importance of various types of externalities in fostering new firm formation and firm growth, locally as well as among more geographically dispersed areas, has implications for the formulation and interpretation of endogenous growth models. Our analyses have revealed marked differences between the effects of agglomeration economies on new firm formation and incumbent firm growth in the Dutch ICT industry. For example, local ICT firm competition has a positive effect on new firm formation, but no effect on incumbent firm growth. Although the other agglomeration indicators to a large extent have the same effect on both new firm formation and incumbent firm growth, they do vary in magnitude (stronger effects of ICT firm concentration, business services concentration, and all firm competition on new firm formation). In general, agglomeration economies have stronger effects on new firm formation than on growth of incumbent firms in the ICT industry. This may be explained by the fact that incumbent firms usually have a wider spatial orientation and that they tend to keep their knowledge inside the company as much as possible in comparison to new firms. The distinction between these two indicators of entrepreneurship thus contributes to the spatial externalities debate. No satisfying formulation has as yet been developed to incorporate these aspects of entrepreneurship fully in endogenous growth models. This paper has shown that there are good reasons to remedy that state of affairs.

Notes

[1] This research has been supported in part by NOW-MES grant 014-43-745.

[2] Although Fingleton *et al.* (2004) argue that the location quotient as an indicator averages over size effects, the measure they propose (the absolute deviation of employment from a location quotient equal

to 1) correlates highly with the measure of location quotients (r=0.76), indicating that the two approaches are not divergent in their application in our analyses.

[3] Due to restrictions of space, correlation diagnostics of all explanatory variables used in this paper are not presented. No correlation higher than 0.5 in absolute terms was included in the analyses.

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Table 3. OLS, spatial lag and spatial regime models for new firm formation (n=580; 1996-2000, t-values in parentheses)

Explanatory variables	(1) OLS	(2) Spatial lag model	(3) Spatial lag model, macro-zoning regimes			(4) Spatial lag model, connectedness regimes		(5) Spatial lag model, urban regimes	
			Randstad	Int. zone	Periphery	Connected	Unconnect.	Urban	Non-urban
CONSTANT	0.853	0.139	-0.340	0.617	0.129	0.039	0.234	0.112	-0.280
	(5.526)	(1.000)	(-1.232)	**(2.071)**	(0.659)	(0.206)	(1.174)	(0.726)	(-0.704)
CONCENTRATION ICT	0.931	0.741	0.879	0.726	0.709	0.817	0.687	0.748	0.779
	(21.218)	**(18.803)**	**(10.783)**	**(7.840)**	**(11.407)**	**(14.474)***	**(12.785)***	**(18.124)**	**(5.956)**
CONCENTRATION MANUFACTURING	-0.015	-0.025	-0.092	0.006	-0.001	-0.009	-0.042	-0.009	-0.147
	(-0.524)	(-0.951)	(-1.702)	(0.125)	(-0.004)	(-0.242)	(-1.153)	(-0.352)	(-1.392)
CONCENTRATION BUS. SERVICES	0.296	0.226	0.328	0.356	0.119	0.333	-0.069	0.201	0.157
	(3.793)	**(3.234)**	**(2.098)**	**(2.839)**	(1.068)	**(3.540)***	(-0.668)*	**(2.704)***	(0.653)*
NON-DIVERSITY	-0.851	-0.408	-1.007	-0.271	0.370	-1.202	0.839	-0.433	-0.631
	(-2.991)	(-1.603)	**(-1.959)**	(-0.552)	(0.879)	**(-3.731)***	**(2.108)***	(-1.504)	(-0.927)
SIZE ICT FIRMS (COMPETITION)	0.944	0.731	0.846	0.687	0.696	0.751	0.759	0.776	0.669
	(18.450)	**(15.933)**	**(10.157)**	**(6.218)**	**(9.098)**	**(12.195)**	**(11.453)**	**(15.188)***	**(5.092)***
SIZE MANUF. FIRMS (COMPETITION)	-0.036	-0.057	-0.106	-0.057	0.002	-0.072	-0.037	-0.044	-0.189
	(-1.037)	(-1.833)	(-1.673)	(-0.969)	(0.039)	(-1.713)	(-0.828)	(-1.353)	(-1.613)
SIZE BUS. SERVICES FIRMS (COMPETITION)	-0.275	-0.182	-0.074	-0.119	-0.290	-0.119	-0.252	-0.192	0.020
	(-5.115)	**(-3.803)**	(-0.708)	(-1.238)	**(-3.966)**	(-1.870)	**(-3.663)**	**(-3.865)***	**(1.966)***
R&D INTENSITY	0.002	0.005	0.041	-0.050	0.006	-0.007	0.017	-0.001	0.079
	(0.145)	(0.351)	(1.158)	(-1.346)	(0.298)	(-0.304)	(0.777)	(-0.009)	(1.507)
W_NEW ICT FIRMS (SPATIAL COEFF.)	-	0.973		0.973		0.970		0.973	
		(15.285)		**(16.447)**		**(10.313)**		**(13.852)**	
Sum. Statistics									
R^2	0.626	0.657		0.669		0.680		0.662	
Max. Likelihood	-499.32	-442.91		-415.034		-412.601		-413.652	
LM (BP)	25.921 (0.000)	21.007 (0.000)		2.592 (0.177)		2.447 (0.117)		2.176 (0.140)	
LM (ρ)	19.745 (0.000)	-		-		-		-	
LM (λ)	26.683 (0.000)	-		-		-		-	
LR (ρ)	-	112.81 (0.000)		104.081 (0.000)		106.66 (0.000)		113.126 (0.000)	
Chow-Wald	-	-		22.174 (0.224)		35.000 (0.000)		29.623 (0.032)	

Values of log-likelihood are not comparable over populations of all and old establishments. Following Anselin *et al*. (1995), LM (ρ) and LM (λ) are statistics for the presence of a spatial lag in the dependent variable and in the residual respectively, with a critical value of 3.84 at the 5 per cent level of significance (marked +). LM (BP) tests for homoscedasticity of regression errors using the Breusch-Pagan Lagrange multiplier test for normal distributed errors. The spatial weight matrix used is w_1 (row standardised), probability levels (p-values) are presented in the tables. Significant p-levels are printed in bold. The spatial Chow-Wald test is distributed as an F variate and tests for structural instability of the regression coefficients over regimes (Anselin 1995, p.32). Significant results (95 per cent confidence interval) of the spatial Chow-Wald in general and on individual coefficients (rejection of H_0 of joint equality of coefficients over regimes) are marked (*). All variables are log transformed and corrected for extreme values. The variables concerning ICT FIRMS are calculated on the population of all ICT firms.

Table 4. OLS and spatial regime models for (log) incumbent firm growth (n=580; 1996-2000, t-values in parentheses)

Explanatory variables	(1) OLS	(2) OLS, macro-zoning regimes			(3) OLS, connectedness regimes		(4) OLS, urban regimes	
		Randstad	Int. Zone	Periphery	Connected	Unconnect.	Urban	Non-urban
CONSTANT	2.409	2.117	2.336	2.607	2.361	2.454	2.519	1.278
	(5.882)	**(2.209)**	**(3.731)**	**(3.316)**	**(3.754)**	**(4.479)**	**(5.808)**	(0.664)
CONCENTRATION ICT	0.728	0.802	0.539	1.235	0.422	1.097	0.674	1.038
	(3.904)	**(2.022)**	**(2.040)**	(2.745)	**(2.043)**	**(3.852)**	**(3.494)**	(1.604)
CONCENTRATION MANUFACTURING	-0.812	-0.595	-0.710	-0.886	-0.335	-1.313	-1.030	0.251
	(-2.238)	(-0.809)	(-1.271)	(-1.315)	(-0.653)	**(-2.531)**	**(-2.702)**	(0.176)
CONCENTRATION BUSINESS SERVICES	0.322	0.908	0.231	1.190	0.546	-0.892	0.970	1.662
	(1.481)	(1.167)	(0.831)	(1.937)	(0.380)	(-1.876)	**(1.962)**	(1.589)
NON-DIVERSITY	-2.280	1.342	-2.516	-2.238	-2.436	1.923	-2.438	0.587
	(-2.873)	(1.549)*	**(-2.173)***	(-1.409)*	**(-2.088)***	(1.540)*	**(-2.949)**	(0.196)
SIZE ICT FIRMS (COMPETITION)	-0.388	-0.604	-0.184	-0.108	-0.796	0.049	-0.789	0.378
	(-0.633)	(-0.537)	(-0.177)	(-0.072)	(-0.871)	(0.058)	(-1.145)	(0.826)
SIZE MANUF. FIRMS (COMP.)	-0.426	-0.350	0.112	-0.475	0.078	-1.012	-0.495	0.584
	(-1.013)	(-1.672)	(0.180)	(-0.587)	(0.127)	(-1.738)	(-1.123)	(0.368)
SIZE BUS. SERVICES FIRMS (COMP.)	-0.056	1.543	-0.825	-0.884	-1.040	0.607	0.157	-1.085
	(-0.088)	**(3.296)***	(-0.828)*	(-1.868)*	(-1.097)	(0.688)	(0.234)	(-1.214)
R&D INTENSITY	0.270	-0.402	0.506	-0.003	0.529	-0.159	0.216	1.024
	(1.192)	(-0.781)*	**(2.631)***	(-0.005)*	**(2.659)***	(-1.049)*	(0.897)	(1.442)
Sum. Statistics								
R^2	0.1469	0.1898			0.1845		0.1634	
LM (BP)	0.304 (0.048)	4.251 (0.092)			1.958 (0.162)		3.845 (0.094)	
LM (ρ)	0.851 (0.356)	-			-		-	
LM (λ)	1.746 (0.186)	-			-		-	
Chow-Wald	-	1.459 (0.083)			1.184 (0.089)		1.110 (0.352)	

See technical explanation below table 3.

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